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UNITED STATES
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HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

SOME PHASES OF HAULAGE ACCIDENT PREVENTION IN ANTHRACITE MINES

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BY

R. D. CURRIE

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME PHASES OF HAULAGE ACCIDENT PREVENTION IN ANTHRACITE MINES[1]

By R. D. Currie[2]

Haulage accidents in the anthracite region cause fewer fatal and lost-time accidents per million man-hours than similar accidents in bituminous mines, a fact that may be accounted for in several ways, but primarily because haulage, in a large part of the region, is restricted to haulage crews operating only on the gangways where most of the miners seldom come in contact with movement or handling of cars and locomotives.

Generally in underground mines the number of men injured compared with the number killed is greater for haulage than for roof-fall accidents, while the number of men killed by haulage is second only to the number killed by roof falls.

When economic losses are considered, haulage accidents probably outrank those of any other type, with the possible exception of mine explosions and fires. Many haulage accidents cause delays, loss of production, and damage to equipment that far exceed the actual compensation and medical costs of personal injuries sustained. In fact, many times there is no injury, while the damage to equipment and other losses are very high.

To the mining industry, transportation underground is as important as railroad transportation on the surface, but it does not receive anywhere near the attention paid to railroad transportation. Mine tracks, especially in chambers, pillars, and secondary roadways, are laid carelessly, frequently with rails and ties that are too light for modern haulage equipment and speeds; this also is often true of main-line haulageways.

The Bureau of Mines has prepared an accident-prevention course for anthracite mines, from which the following list of questions and answers on the prevention of haulage accidents is taken. These questions are used in class discussions to induce thought and the consideration of the conditions that lead to haulage accidents; the answers are suggestions or recommendations by Bureau engineers for the elimination of these hazards.

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Questions and Answers on Prevention of Haulage Accidents in Anthracite Mines

Question 1. What is transportation?

Transportation is the main connecting link between production and preparation; it comprises all of the methods used to transport or move coal and rock from the face to the preparation plant or breaker, including gathering of cars by locomotives, animals, rope, or man power; conveyors, drag shovels, skips, shaker chutes, and, in pitch work, the breasts and coal chutes; main-line haulage by locomotives, animals, rope, conveyor, planes, slopes, or manpower; hoisting in shafts or slopes, and movement of coal from the pit mouth, shaft, or slope into the breaker by car or otherwise. It also includes all hauling of men, materials and supplies.

Question 2. What are the general methods of transportation used in anthracite mines?

All of the above-mentioned methods of transportation are used in some anthracite mines, although the use of conveyors has been limited to short lengths in face or long-wall work, with the exception of two installations, where it is the principal mode of transportation. Locomotive haulage, by electric trolley, cable-reel, storage battery, and compressed air, has to a great extent replaced animal haulage, which predominated until about 1915.

Shaft hoisting to the surface prevails in the Northern Field, while slope openings from the surface to the underground workings are more general in the other anthracite fields.

Question 3. What is the tendency with regard to speed of transportation?

Transportation speed has, on the whole, been increased to a marked degree with the replacement of animals by locomotives and with the use of mechanical loading, which requires fast transportation to make it efficient.

Question 4. What is the effect of increased speed on the number and severity of transportation accidents?

If the general conditions of equipment and track are maintained as they were for slow transportation, an increased speed will increase both the number and severity of transportation accidents.

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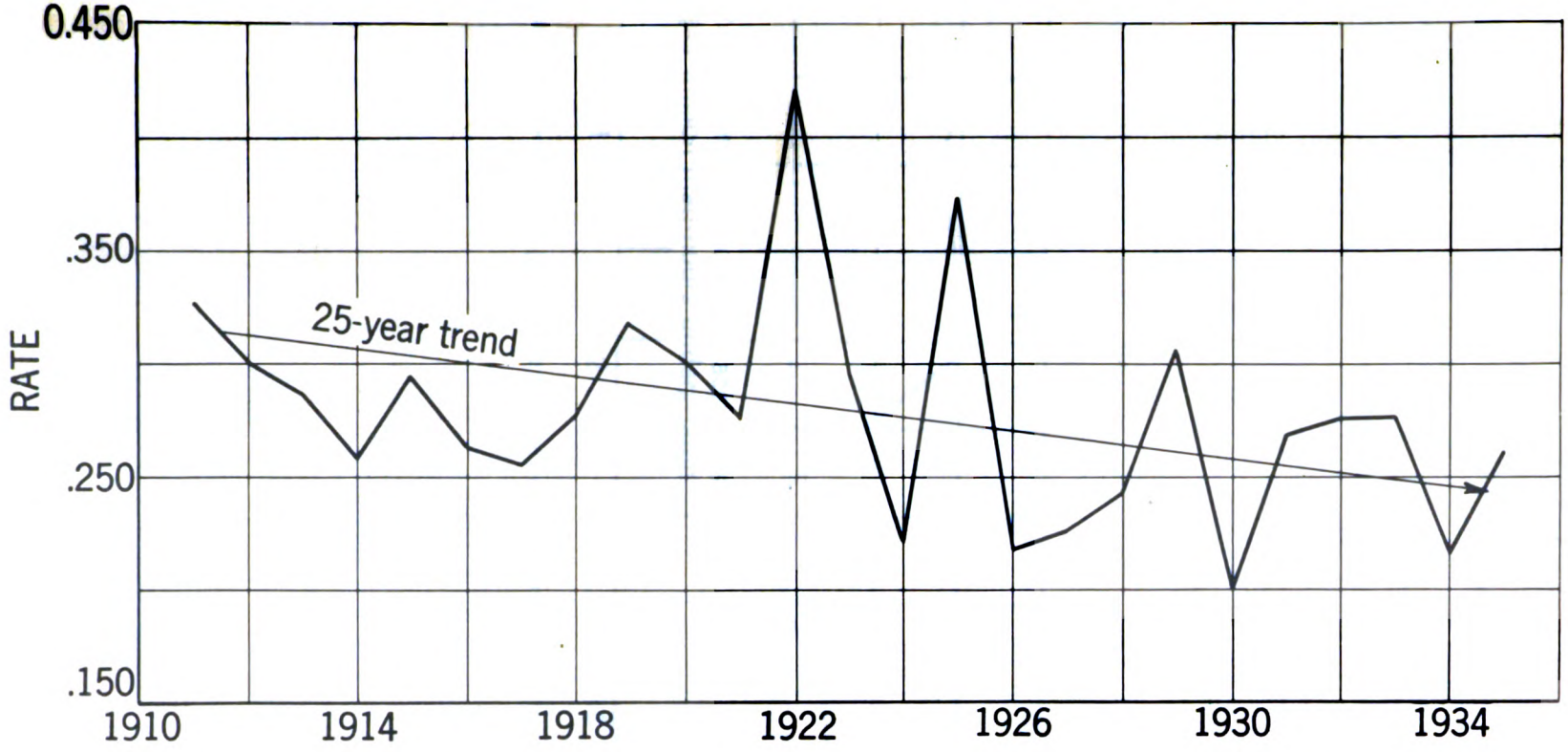

Figure 1.- Fatality rate, per million man-hours, for haulage in anthracite mines - 1911-1935.

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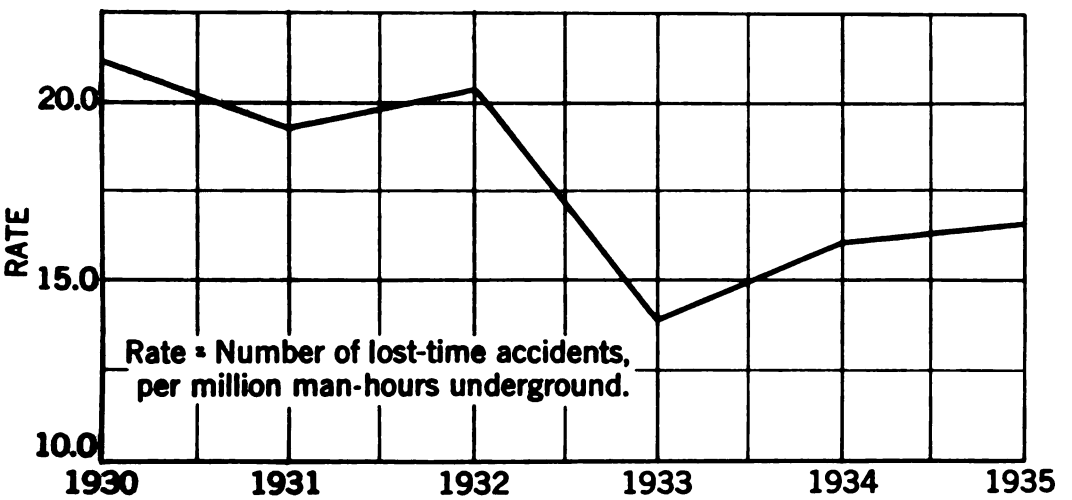

Figure 2.- Haulage injury rates - anthracite mines.

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Question 5. What is the tendency of anthracite transportation accidents, compared with statistics of the past 25 years?

The following tables show that the trend of haulage fatalities has been downward over the 25-year period, 1911 to 1935; although there have been bad peak years during that time, and the lost-time accident rates per million man-hours of exposure from all causes show an upward trend over the past 6 years, the haulage accident trend is downward. It should be noted that lost-time accident statistics are available for only a 6-year period, 1930 to 1935, inclusive. It should be noted also (see figure 1) that the trend in accident statistics over a short period, say 6 years, may be entirely different from the trend over a much longer period.

The charts accompanying the tables give a graphic interpretation of these statistics. Figure 1 gives the fatality rate per million man-hours from 1911 to 1935, inclusive, while figure 2 gives the lost-time accident rate per million man-hours, for the period 1930 to 1935, inclusive. This latter figure has more significance in haulage because a large percentage of haulage accidents are nonfatal, lost-time accidents.

TABLE 1. - Haulage fatalities and rates per million man-hours underground

Year	No. of fatalities	Fatality rate	Year	No. of fatalities	Fatality rate
1911..	92	0.328	1924..	58	0.222
1912..	79	.300	1925..	56	.375
1913..	85	.288	1926..	52	.218
1914..	76	.258	1927..	52	.226
1915..	80	.295	1928..	52	.242
1916..	64	.263	1929..	65	.306
1917..	64	.255	1930..	40	.200
1918..	66	.277	1931..	43	.269
1919..	73	.318	1932..	33	.277
1920..	66	.301	1933..	32	.277
1921..	70	.276	1934..	29	.216
1922..	58	.420	1935..	30	.261
1923..	73	9.297			

TABLE 2. - Haulage injury rates per million man-hours underground

Year	Injury rate (haulage)	Injury rate (all accidents)
1930...	21.033	129.103
1931...	19.138	126.546
1932...	20.333	144.752
1933...	13.951	114.902
1934...	16.055	133.338
1935...	16.635	132.274

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Question 6. What are some of the principal hazards of transportation?

The principal causes of haulage accidents, and therefore the more common hazards, in connection with transportation, are outlined by the Bureau of Mines as follows:

MINE CARS AND MINE LOCOMOTIVES:

A. Struck, run over, or squeezed between cars of locomotives.

(1) While coupling,
(2) While switching, spragging, blocking, braking,
(3) While pulling or pushing cars,
(4) While operating or riding trip,
(5) All others.

B. Squeezed between car and rib, timber, or roof.

(1) While coupling,
(2) While switching, spragging, blocking, braking,
(3) While pulling or pushing cars,
(4) While operating or riding trip,
(5) All others.

C. Derailments

D. Rerailing cars.

E. Pulling or pushing cars by hand, strain from,

F. Animals on haulage.

G. Falling from cars (not run over)

H. Runaway cars on dips or slopes.

I. Other haulage accidents.

Question 7. What can and is being done in anthracite mines to eliminat reduce, or control accidents from these causes?

(1) Struck, run over, or squeezed while coupling:

There are a number of remedies for accidents of this type:

(1) Proper clearance along all haulage roads, more especially at coupling points, switches, loading stations, shaft bottoms, etc. (this perhaps is the most important); (2) properly designed bumpers on cars and locomotives, with special thought

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to clearance between cars on the ordinary curves found in mines; (3) elimation of the usual link and pin, links, hooks, and clevices, and the installation of automatic couplings or semi-automatic couplings, wherever possible. It is realized that modern design of automatic and semiautomatic couplings is not entirely suitable for anthracite mines where slopes and planes, with knuckles or "dishes", are used, but certain designs can be made that meet the needs of anthracite mines, or slopes and planes can be regraded at knuckles and dishes to facilitate the use of these safer couplings.

(2) Struck, run over, or squeezed while switching, spragging, blocking, and braking:

Here again clearance is the main consideration; adequate clearance is imperative at all switches, with a shelter hole at each switch; switch throws should be of a type that moves parallel to the track and the handle should be back in the clear from the track and cars; no switch should be installed without a throw; switch points and frogs should be of proper design and should be inspected frequently to insure proper maintenance; all frogs should be shrouded or guarded; main line switches should have suitable signals or markers, operating automatically, in conjunction with them.

Spragging of cars is so inefficient and hazardous that the use of sprags should be prohibited; nevertheless, there are many mines still using sprags and their use will probably continue until such time as mine car brakes have been perfected to the point where they are deemed indispensable.

Mine car brakes, and the use or misuse of them have accounted for many mine accidents, as has the practice of running alongside moving trips to apply or release brakes, and falling, slipping, stumbling or being squeezed in a tight place between cars or locomotive and rib or timber, between cars, or run over by cars. These accidents can be prevented, or greatly reduced, by maintaining proper clearance, by using brakes of proper design, and by adequate supervision to insure observance of regulations as to when, where, and how to apply or release brakes.

Squeezed while blocking usually occurs at shaft bottoms, and heads of planes and slopes. There is little excuse for inadequate clearance at these points, although in the layout at many mines too little clearance is allowed between parallel tracks at such points, and frequently the clearance between cars and rib or timbers has been skimped.

Automatic car retarders and car stops of suitable mechanical design and proper layout, will eliminate this hazard.

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(3) Struck, run over, or squeezed while pulling or pushing cars:

Here again the matter of clearance is of paramount importance. Elimination of much of the manual placement and handling of cars in mines is desirable; frequently, however, mechanical devices for handling cars are so designed or installed that they increase the hazards instead of reducing them. A properly designed haulage and gathering system, which confines the handling or moving of cars to competent haulage crews, with properly designed equipment and adequate clearance should greatly reduce or possibly eliminate this type of accident.

(4) Struck, run over, or squeezed while operating or riding trip:

This type of accident generally occurs to the brakeman or motorman's helper, and is generally attributed to inadequate clearance, unsafe practices, including lack of supervision, and inadequate provisions for the safety of this employee when riding on trips. In anthracite mines pushed trips are the rule, rather than the exception, and the hazard to persons riding on pushed trips is far greater than when riding on trips being pulled.

In general, the cab-room on locomotives is insufficient for the safety of the operator and no provisions are made for the safety of his helper.

Safety rules should provide that no trips should be pushed while it is possible to make provision for pulling them; if trips must be pushed, the brakeman should place a signal light and gong on the front end, and then get on the locomotive, in a safe place; pushed trips must be operated with greater caution and at a lower speed than pulled trips to attain the same degree of safety.

Ordinarily roof clearance is not a problem in anthracite mines where trips are hauled, but there are times and places where collars on timber sets may be low, or where bottom has heaved or roof squeezed, thus creating a hazard to the motorman and brakeman. Such hazards should be remedied; or these places should be suitably marked by illumination, and motormen and their helpers must use every precaution at such hazardous places. On gangways, where loading chutes extend below the level of the timbers, there is a distinct hazard to persons riding on trips. This hazard can be reduced by properly designed and properly located chute spouts and by restricting the habit of riding on trips.

C. Derailments:

The prevention of accidents from derailments depends primarily on the prevention of derailments. In mine haulage, too frequently,

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poorly graded and poorly installed track of rails, ties, frogs, etc., of insufficient size is used, with a high rate of derailment ocurrence. Rolling stock of poor design is roughly used and poorly maintained, which increases the number and seriousness of derailments; and speed is frequently substituted for plan and forethought, which increases the number and seriousness of wrecks.

A few companies have established standards of track design, installation, and maintenance; some have designed mine cars with a thought to "trackability" and maintenance; a few have established transportation schedules and dispatch systems to maintain control of haulage crews. All of these are essential to eliminate derailments, with their resultant injuries, damage to track and equipment, and loss of tonnage.

D. Rerailing cars:

The essential remedy is to eliminate, insofar as possible, the derailments. There are, however, relatively safe and unsafe methods of rerailing cars, and very frequently unsafe methods are employed.

Every locomotive operating in a mine should be equipped with a suitable lift-jack of adequate size and a pair of rerailers of correct design. Locomotive crews should be instructed in the proper use of this equipment.

Rigid rules should be enforced requiring the motorman's helper to get in the clear before signalling the operator to move the trip, and prohibiting him from placing his hands or feet on any part of the derailed car, or doing any blocking, after the signal is given.

A clear and distinct set of signs should be standardized and a suitable type whistle should be used to give such signals.

In some mines a permanent rerailer is built into the main haulageway at all main switches to automatically rerail cars at these points. It is believed, however, that if the cost of building these rerailers and maintaining them was expended on preventing the derailments, they would not be needed.

E. Pulling or pushing cars by hand:

Accidents from this cause can be reduced to a minimum by (1) reducing the amount of manual handling of cars to a minimum, (2) maintaining proper clearance, (3) instruction in safe methods of handling cars, and (4) properly designed cars.

F. Animals on haulage:

Accidents from animals on haulage are being greatly reduced by replacing animals with mechanical equipment. However, the great

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reduction in the number of animals at some mines has been cause for abandoning many of the safeguards for this type of haulage, so that the few animals still in use at these mines offer more hazards than they should.

Animals with bad accident records should not be used in mines, and considerable care should be taken in choosing devices and in overseeing and supervising their work.

G. Falling from cars:

The hazard of falling from cars can and should be eliminated by properly designed "grab-irons" on all cars; by bumpers of proper size to allow standing room; and by a suitably designed portable seat for brakemen, who must ride on cars. No person should be allowed to ride on or in cars or locomotives except haulage men or such others as are given definite authorization to ride.

H. Runaway trips on dips or slopes:

Runaway trips may be caused by any one of several known failures: (1) Loss of control by locomotive operators on heavy grades or of hoistmen in handling skips or trips on slopes; (2) breaking of ropes, couplings, or draw bars; (3) improper blocking or no blocking; and (4) lack of forethought on the part of haulage crews or others.

To eliminate runaway trips from the causes enumerated, requires, first of all, suitably designed equipment locomotives, hoists, cars, skips, couplings, etc., properly maintained; an organized and supervised haulage plant; limitation of size of trips to the capacity of the locomotive and steepness of grades; frequent inspections of ropes, couplings, and chains by a competent person; annealing of chains, links, and pins at definite stated intervals. This applies particularly to locomotive couplings, slope couplings and chains; a system of blocking all cars and trips standing on grades, in addition to brakes or sprags; and finally, a well-trained and carefully supervised group of haulage men, who have been instructed in the fundamental fact that safe transportation will get out more coal with less effort and cost than transportation surrounded with relatively few precautionary measures.

I. Other haulage accidents:

The eight preceding groups cover most of the causes found at most mines. However, all mines have, at some time or another, accidents that are hard to classify; others may be of such rare nature that they are not classified; or there may be mines where accident investigation has not yet progressed to the point where clear-cut classification is possible.

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Question 8. Are there any transportation accidents in anthracite mines other than those listed in question 6?

Yes, the list of haulage accident causes in the answer to question 6 covers only underground haulage; in addition, there are accidents in connection with surface transportation, and shaft and slope accidents, as well as many accidents otherwise classified as rushes of coal at chutes, and injuries caused by mechanical loading units, conveyors, and scrapers. In 1935 there were 10 fatal and 103 nonfatal lost-time accidents in shafts and slopes in anthracite mines, 304 nonfatal lost-time haulage accidents on the surface, including breaker, shops, and yard; 116 railway car and locomotive accidents, including two fatalities; and 203 lost-time accidents due to mechanical loading equipment and conveyors. In addition to these there were 15 fatal and 333 nonfatal accidents from rushes of coal, rock or gob, most of which were probably in connection with transporting this material from the face in the chute.

Question 9. What should be the capacity of shaft hoisting engines?

The shaft hoisting engines should have sufficient power to hoist the maximum load easily, unbalanced.

Question 10. What should be the capacity of the brakes on shaft engines?

They should be powerful enough to stop and hold the maximum load, unbalanced.

Question 11. What equipment should be included on all shaft engine installations?

(a) Indicator dial
(b) Overspeed control
(c) Overwind control
(d) At least two systems of signalling, one of which should be verbal.

Question 12. What should be the qualifications for hoisting engineers?

They should be at least 21 years of age, sober, competent, and in good physical condition. They should be given a thorough physical examination once a year, including especially the heart, sight, and hearing.

Question 13. What type of signal should be used at shafts?

Clear, audible, and distinct signals should be used, and the signal code should be standard for all shafts in the anthracite region.

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Question 14. What code of signals would you recommend?

Pennsylvania Mining Law for the Bituminous Region has for years included the following code. This code, with the necessary additions to designate intermediate levels, should be made standard at all mines in Pennsylvania.

One rap or whistle - to hoist coal.
One rap or whistle - to stop car or cage when in motion.
Two raps or whistles - to lower car or cage.
Three raps or whistles - to hoist persons. The engineer shall signal back when ready, after which the persons shall get on the car or cage, and then one rap or whistle shall be given to hoist.

Question 15. What should be the safety factor of shaft hoisting ropes

(a)	500 feet or less in depth	8
(b)	500 to 1000 feet in depth	7
(c)	1000 to 2000 do	6
(d)	2000 to 3000 do	5
(e)	3000 feet and over in depth	4-1/2

Safety factors above this weight of the rope off-set the advantage gained.

Question 16. What should be the size of shaft hoisting ropes?

Flexibility and use govern the choice, but 2-1/2 inches is considered the largest practical size. If larger sizes are needed, flat ropes are preferable but there are numerous objections to using flat ropes.

Question 17. How should shaft ropes be attached to the drum?

The ropes should be attached securely to the side of the drum by suitable clamps and at least one full turn of rope should remain on the drum when the cage is in the lowest position in the shaft.

Question 18. How should shaft ropes be attached to the cage or skip

There are two general methods, but the recommended practice is to use a suitable thimble and at least six clamps; this method makes a connection that is easy to inspect, and requires no heat treatment. The more generally used method is to attach a socket to the end of the rope.

Question 19. What precautions must be observed in socketing rope?

The attaching of a socket to a rope requires skill and care if the completed job is to be safe. The rope end must be whipped to prevent unwinding, the rope kept straight, then the end

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cleaned with half-strength muriatic acid and wiped dry. Pure zinc (spelter) only should be used for socketing. Babitt, lead and other metals sometimes used are distinctly unsuitable.

Question 20. What are the weak points of a rope socket?

The temper line at the top of the socket due to heat and imperfect adhesion or cohesion inside the socket, caused by improper cleaning, air bubbles, or insufficient zinc.

Question 21. When should shaft ropes be resocketed?

Shaft ropes should be resocketed at periods not to exceed 4 months (some companies resocket every 90 days). In resocketing at least 4 feet should be cut off the end of the rope so an entirely new section of rope will be on the sheave when the cage is at the loading position.

Question 22. What governs the safe life of a rope in shaft use, and how can inspection reveal weaknesses of such rope?

The safe life of a rope is determined by stretch, broken wire count, wear of crown, time in service, trips made, tonnage hoisted, ton-miles, and corrosion; none of these methods are very definite and ropes fail at times even when utmost care is taken in inspection. In any event, ropes should be discarded when inspection reveals six broken wires in one rope lay; or when crown wires are worn to 65 percent of the original diameter; or if corrosion is evident, or stretch is gone.

Question 23. What are the danger points in shaft hoisting and how often should they be examined?

The danger points, which should be examined at least daily, and a written report made, are: Ropes, safety catches, hitching to cages including sockets and bridle chains, and sheave wheels for wear and breaks.

Question 24. How should the cages be constructed and equipped where men are handled?

Cages should be sturdy and strong enough to carry the load; all bolts and rivets must be in place; sturdy bonnet, automatic safety catches, end gates, bars or chains, hand-holds and bridle chains should be provided, and all maintained in the safest possible condition. Where practicable, signals and communication direct from the cage to the engineer by a two-way communication system should be installed on man hoists. All cages on which men are hoisted should be provided with doors and the doors should be kept closed at all times when the cage carrying men is in motion.

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Question 25. What safety equipment or devices should be provided at shaft landings?

Automatic safety gates, automatic blocks and/or switches, and a turnstile should be provided at surface landings.

Automatic gates, blocks and switches, and screen guards should be provided at intermediate landings and bottoms, while at coal hoisting levels automatic cagers and car stops should be included.

Question 26. What safety devices should be included in slope hoisting equipment, where men are handled?

Slope hoisting equipment should be designed and selected as carefully as that for shafts, and in general the safety equipment recommended for shafts also applies to slopes, except that the attachment of the rope should always be by a socket because clamps would be prone to catch on ties and track.

Although there are no slopes in the anthracite region equipped with automatic controls to prevent runaway of the man-car in case of failure of the rope or couplings, such devices are available, and have been in use in other mining districts for years. A working model of one type of safety car has been shown to a number of anthracite officials and most of them have agreed as to the necessity of such a device and the utility of the design.

Question 27. What "Safety Rules" should be established in connection with locomotive haulage?

Safety rules, to be effective, must be based on common sense and fairness; once established they must be strictly enforced if they are to be of any material benefit; a few typical rules, taken from company rule books, are given herewith:

(a) Locomotives, including controllers, brakes, headlights, and other equipment must be maintained in safe operating condition; any defects must be reported immediately to transportation foreman or mine foreman.

(b) No one is permitted to ride on locomotives or loaded cars except haulage crews in course of their duties.

(c) No one is permitted to ride in empty cars except the haulage crews in course of their duties, unless such cars are being operated as a "Man trip."

(d) Man trips shall be operated with due precaution, and at no time shall speeds of 6 miles per hour be exceeded.

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(e) Locomotives and trips must come to a full stop to open doors, throw switches, or make and break couplings.

(f) Haulage crews must wear neat fitting clothing. Cords on electric cap lamps must be worn under jacket or suspenders.

CONCLUSIONS

Haulage, or transportation, accidents, like other types of mine accidents are avoidable. Poorly designed, constructed, and maintained equipment and haste and lack of supervision of haulage crews will continue to account for many accidents in connection with transportation. With properly designed, constructed, and maintained haulage equipment, together with properly trained haulage crews, adequately supervised, any mine in the anthracite region could have an almost perfect record in connection with haulage.

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